Journal of Agricultural Sciences Research

ISSN 2764-0973 vol. 6, n. 1, 2026

ARTICLE 8

Data de Aceite: 02/03/2026

LAND USE AND LAND COVER IN SARANDI, PARANÁ, IN THE EARLY 21ST CENTURY (2001-2024)

Renan Valério Eduvirgem
Professor in the Department of Geography at the State University of Maringá (UEM)

Jully Jesús de La Cruz Cisneros
PhD in Genetics and Breeding (UEM)

André Jesus Periçato
Professor, Department of Geography, State University of Maringá (UEM)

All content published in this journal is licensed under the Creative Commons Attribution 4.0 International License (CC BY 4.0).

Abstract: This study analyzes the dynamics of land use and coverage in the municipality of Sarandi (PR), from 2001 to 2024, with an emphasis on urban expansion and changes in the agricultural production structure. Based on a multitemporal analysis of spatial data (MAPBIOMAS), significant changes were identified in both urban and rural areas. The results show that the urban area has practically doubled in just over two decades, consolidating the process of conurbation with the municipality of Maringá. In rural areas, there was a significant reduction in pasture areas and sugarcane cultivation, parallel to the expansion of soybeans, which consolidated its position as the main local agricultural crop. This dynamic reflects the trend toward productive specialization observed in northern Paraná, associated with favorable soil conditions and the economic relevance of the crop. An increase in the class of forest formations was also identified, possibly related to the strengthening of environmental legislation. Thus, Sarandi is undergoing a process of territorial transition, requiring land use policies that reconcile urban growth, agricultural productivity, and environmental conservation.

Keywords: Soybean expansion; urban expansion; territorial dynamics; land use and land cover; multitemporal analysis.

INTRODUCTION

Studies on land use and land cover are fundamental for monitoring and understanding the transformations that have occurred in geographical space over time, as they produce information and results that can be used in consistent territorial planning and management.

Nigro *et al.* (2025) note that over the last few decades, anthropogenic actions on terrestrial landscapes have caused the degradation of ecosystems and led to significant losses in biodiversity. In this context, land use and land cover maps are fundamental for promoting monitoring.

In addition, land use and land cover have become established as a relevant methodological approach for understanding the dynamics of urban growth, as evidenced in studies by Altmann, Eckhardt, and Rempel (2009), Mandal, Ghosh, and Mukhopadhyay (2019), and Vale *et al.* (2021).

Data from the MapBiomas project are used in several studies, including Conceição *et al.* (2025), Pessoa *et al.* (2025), and Silva *et al.* (2026). The project was developed in Brazil and has expanded widely, currently covering 14 countries throughout South America and Indonesia, which reinforces its relevance and application in different geographical contexts (MAPBIOMAS, 2026).

This study aims to analyze the dynamics of land use and land cover in the municipality of Sarandi, Paraná, based on data from the MapBiomas Brasil project. The analysis is based on a multitemporal comparison between the years 2001, 2012, and 2024, using Collection 10, without making any adjustments or edits to the original mapping. The starting point is the hypothesis that, over the period analyzed, there was an expansion of the urban area and soybean classes in the municipality.

METHODOLOGICAL PROCEDURES

LOCATION OF THE STUDY MUNICIPALITY

The municipality of Sarandi is located in the northern part of the state of Paraná (Figure 01), bordering the municipalities of Maringá and Marialva. It should be noted that Sarandi and Maringá constitute an urban conurbation, characterized by the spatial continuity of the urban fabric, without clearly defined physical boundaries between the two urban centers (Rossatto *et al.*, 2020).

According to population estimates by the Brazilian Institute of Geography and Statistics (IBGE) for the year 2025, Sarandi has a population of 128,106 inhabitants and a population density of over 1,000 inhabitants per square kilometer (IBGE, 2025).

In terms of vegetation, there is a Semi-deciduous Seasonal Forest (FES), characterized by tree species with a woody stratum and partial loss of foliage during the winter period (IBGE, 2012).

In terms of climate, the municipality of Sarandi falls into class Cfa according to the Köppen climate classification, which corresponds to a humid subtropical climate, marked by well-distributed rainfall throughout the year and hot summers (Alvares *et al.*, 2014).

OFFICE PROCEDURES

Information on land use and land cover was obtained from the MapBiomas database (MAPBIOMAS, 2025), without making any adjustments or edits to the

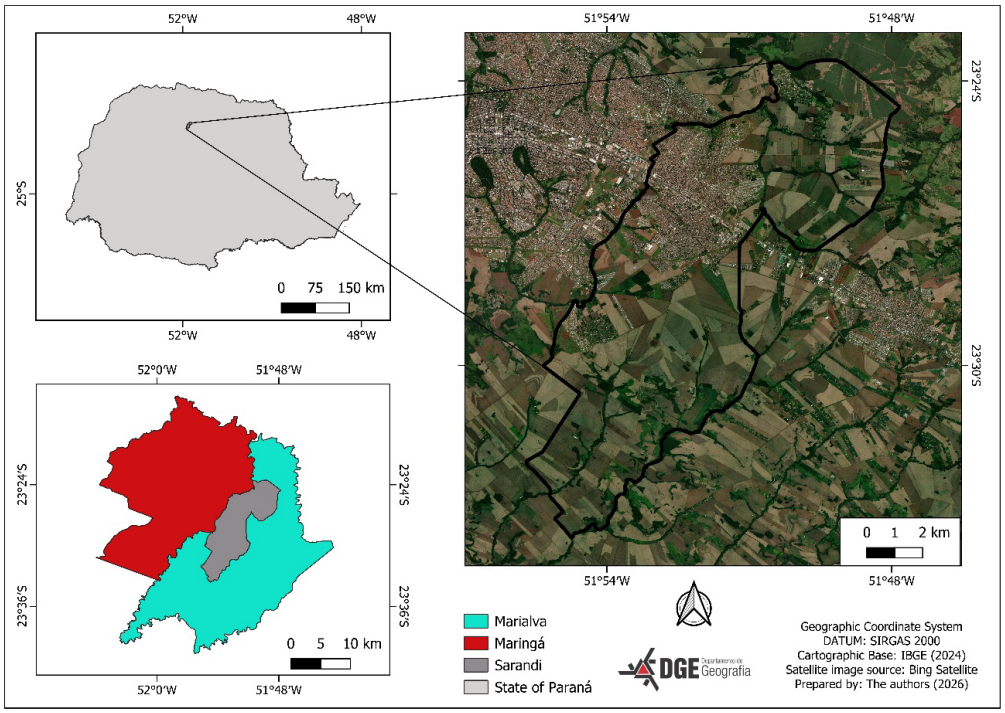

Figure 01 – Location map of the study area

Source: The authors (2026)

original mapping. For the present analysis, Collection 10 was used, considering the years 2001, 2012, and 2024.

The maps were created using QGIS software (version 3.34.7), while the graphs were created using the Python 3 programming language, with the use of the pandas and matplotlib packages, including the MultipleLocator module from matplotlib. ticker.

RESULTS AND DISCUSSION

The land use and land cover classes presented in this study consist of forest formation, forest plantation, wetland, pasture, sugar cane, mosaic of uses, urban area, other non-vegetated areas, water bodies, soybean, other temporary crops, coffee, and other perennial crops.

As mentioned earlier, this study did not make any changes to the original MapBiomas mapping. However, it should be noted that the river and lake class was only renamed as water bodies, without any changes to its spatial delimitation or classification criteria.

The forest plantation class began to be identified in the 2012 mapping, with an area of 0.01 km², reaching 0.07 km² in 2024. This increase corresponds to a growth of 0.06 km², representing a 600% increase (Figures 2, 3, and 4 B). The water bodies class is not recorded in the 2012 mapping. In 2001, this class had an area of 0.04 km², while in 2024 it totaled 0.03 km² (Figures 02 and 03).

The forest formation class showed continuous growth throughout the period analyzed, with a gradual increase in its area. In 2001, this class occupied 3.12 km², in-

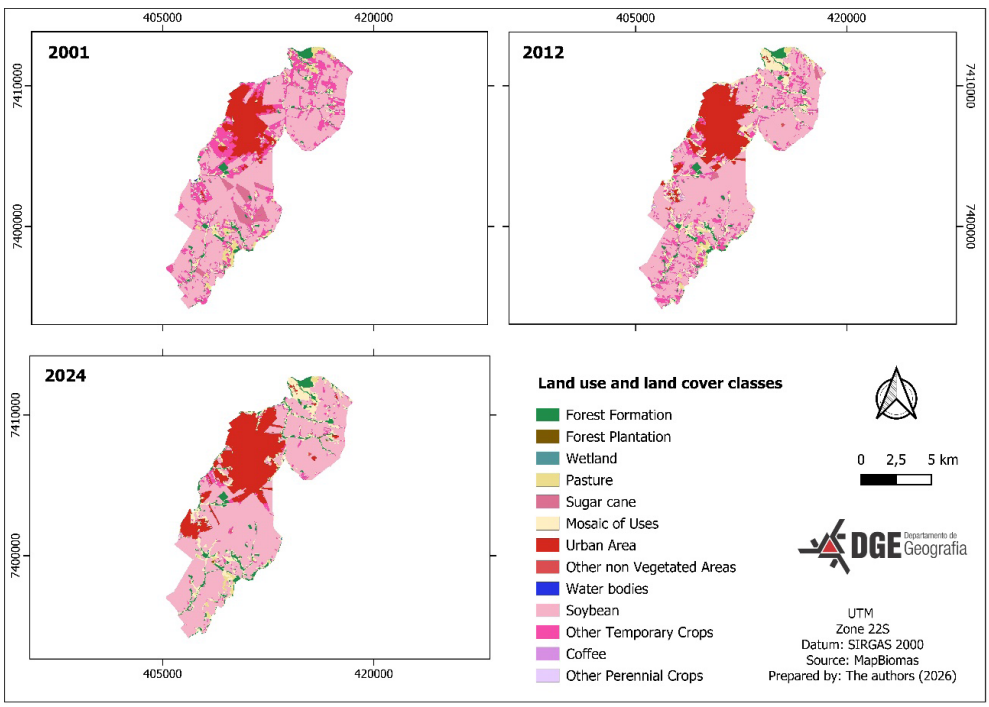

Figure 02 – Land use and land cover in the municipality of Sarandi, Paraná

Source: The authors (2026)

creasing to 3.54 km² in 2012 and reaching 5.15 km² in 2024. Spatial analysis shows that the most significant increase occurred between 2012 and 2024, which may be associated with the strengthening of actions aimed at complying with the environmental legislation established by the New Forest Code (Law No. 12,651/2012) (Brazil, 2012). This class is present in both the southern and northern parts of the municipality of Sarandi, with a notable concentration in Permanent Preservation Areas (APPs), where it is easily identified (Figures 02 and 03).

However, it is worth taking a critical look at this increase in the forest formation class. In a study conducted by Nigro and Ferreira (2021), which analyzed forest restoration in the valley bottom areas along the Cleópatra and Moscados streams in Maringá (PR), it was evident that, although there was an increase in forest cover in these areas, several sections still show signs of environmental degradation, associated with low species diversity and the significant presence of invasive alien species.

The forest formation class showed an increase in area of 0.42 km² between 2001 and 2012, corresponding to a gain of 13.46% (Figure 4 A). Between 2012 and 2024, the increase was 1.61 km², representing an increase of 45.48% (Figure 4 B). Considering the entire interval analyzed, from 2001 to 2024, the cumulative growth was 2.03 km², equivalent to a percentage gain of 65.06% (Figure 4 C).

The wetland class also showed gradual growth over the period analyzed. In 2001, this class occupied 0.004 km², increasing to 0.01 km² in 2012 and reaching 0.02 km² in 2024 (Figures 2 and 3). The growth of this class was 150% in the period between 2001 and 2012 (Figure 4 A), 100% between 2012 and 2024 (Figure 4 B), and 400% considering the entire interval analyzed, from 2001 to 2024 (Figure 4 C).

In turn, the pasture class decreased over the period studied (Figures 02 and 03). In 2001, the pasture class occupied an area of 3.28 km², reducing to 1.69 km² in 2012 and to 1.12 km² in 2024 (Figure 3). Considering the period from 2001 to 2012, there was a 48.48% reduction in the pasture class area. Between 2012 and 2024, the loss was 33.73%. Throughout the entire period analyzed, from 2001 to 2024, the cumulative reduction in this class reached 65.85% (Figures 4 A, 4 B, and 4 C).

The decrease in pasture areas was analyzed by Paiva and Nóbrega (2010), who studied the evolution of land use in northwestern Paraná between 1972 and 2006. As evidenced in the present study for the municipality of Sarandi, areas previously occupied by pastures were gradually replaced by other agricultural crops, notably sugarcane, especially in the northwestern portion of the state, and soybeans, predominant in the northern portion of Paraná. This behavior is directly related to the pedological characteristics of these regions. In the case of Sarandi, fertile, clayey, and well-developed soils predominate, a condition that favored the replacement of certain crops with soybean cultivation.

In this context of land use "restructuring" and crop substitution, it can be observed that this dynamic also had a direct impact on the sugarcane class in the municipality of Sarandi. In the sample analyzed, there was a continuous decline in this crop over the years. In 2001, this class occupied an area of 2.93 km², which was reduced to 0.41 km² in 2012 and to only 0.05 km² in

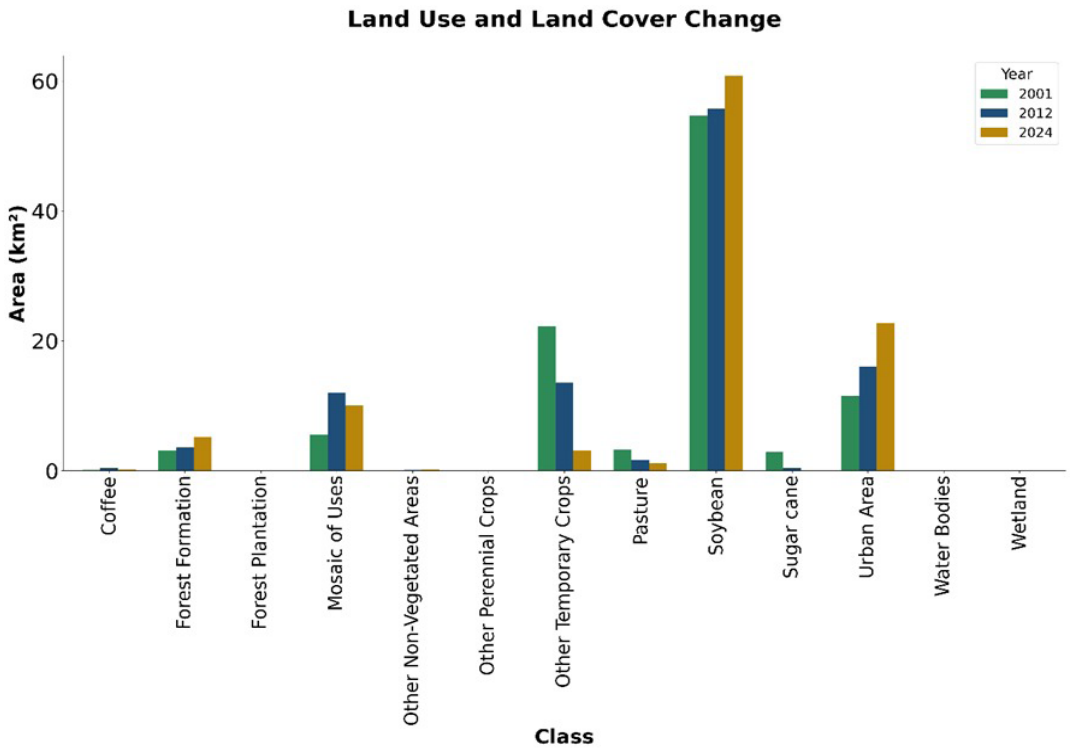

Figure 03 - Area (km²) of land use and land cover classes

Prepared by: The authors (2026). Source: MapBiomas.

2024 (Figures 02 and 03). The sugar cane class showed a reduction of 86.01% in the period between 2001 and 2012. Between 2012 and 2024, the decrease was 87.80%. Considering the entire interval analyzed, from 2001 to 2024, the cumulative reduction in this class reached 98.29% (Figures 04 A, B, and C).

Another class that showed significant growth over the period analyzed was urban area (Figures 2 and 3). In 2001, this class occupied 11.51 km², expanding to 15.98 km² in 2012 and reaching 22.77 km² in 2024 (Figure 3). Between 2001 and 2012, the urban area class increased by 38.84% (Figure 4 A). Between 2012 and 2024, growth was 42.49% (Figure 4 B). Considering the entire period analyzed, from 2001 to 2024, the cumulative increase in this class reached 97.83% (Figure 4 C).

This growth becomes evident when analyzing the demographic density and population evolution of the municipality over the last few years. According to the IBGE (2025), Sarandi currently has the fifth highest demographic density in the state of Paraná, with more than 1,000 inhabitants per km². By way of comparison, Maringá, a neighboring municipality, has approximately 841 inhabitants per km². This scenario results from the combination of significant population growth in recent decades and the small size of Sarandi, factors that intensify demographic concentration.

The significant decline in sugarcane and pasture in the municipality indicates a process of productive substitution over the

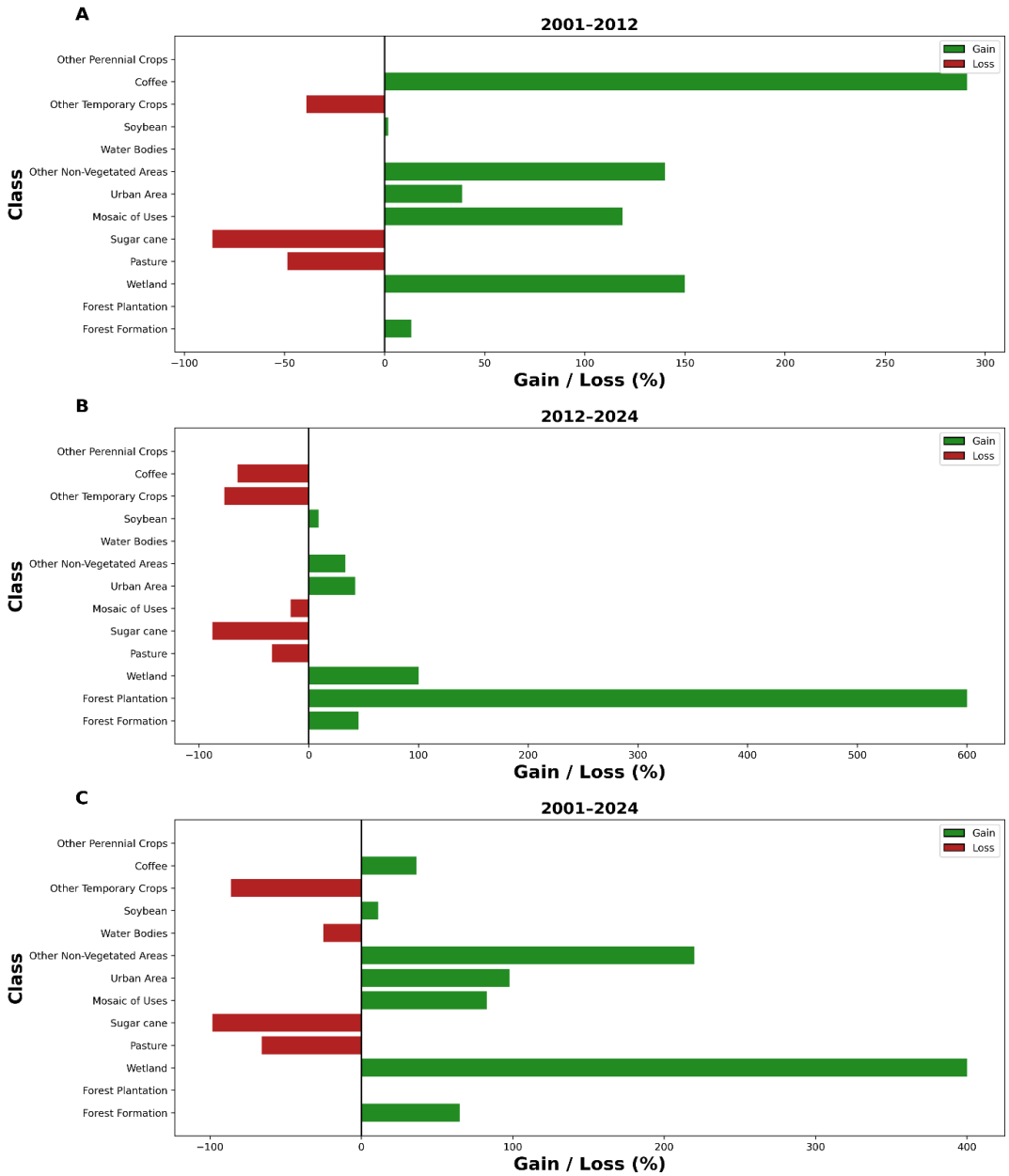

Figure 04 - Change in land use and land cover in Sarandi, Paraná. A) 2001-2012, B) 2012-2024, C) 2001-2024

Prepared by: The authors (2026). Source: MapBiomas.

period analyzed. Part of these areas was incorporated by more competitive crops in the regional context, among which soybeans stand out, as already mentioned, which consolidated their predominance in the local agrarian structure.

Soybeans constitute the largest crop in terms of area in the municipality of Sarandi and also grew over the period analyzed (Figures 2 and 3). In 2001, this class occupied 54.70 km², increasing to 55.72 km² in 2012 and reaching 60.79 km² in 2024 (Figure 3).

The expansion of soybeans occurred continuously, but with different magnitudes between the time intervals evaluated. Between 2001 and 2012, the increase was relatively modest, corresponding to 1.86%. From 2012 to 2024, however, there was more significant growth of 9.10%. Considering the entire period analyzed, from 2001 to 2024, the cumulative increase in the soybean class was 11.13% (Figures 4 A, 4 B, and 4 C).

According to data from the Paraná State Department of Agriculture and Supply (SEAB), soybeans stood out in 2024 as the main agricultural crop in the municipality of Sarandi, as well as in the Maringá Regional Center. In the municipality's arable areas as a whole, soybeans and corn, both classified as temporary crops, had the largest share of Gross Production Value (GPV) when compared to other crops, highlighting their centrality in the local economic dynamic.

In relation to the coffee class, in 2001 the area occupied corresponded to 0.11 km², increasing to 0.43 km² in 2012. However, in 2024 this class showed a reduction, totaling 0.15 km². This behavior shows initial growth followed by a decline in the subsequent period, as illustrated in Figures 2 and 3.

Between 2001 and 2012, the coffee class showed a gain of 0.32 km², corresponding to an increase of 290.91%. In contrast, between 2012 and 2024, there was a reduction of 0.28 km², equivalent to a decrease of 65.12%. Considering the entire interval analyzed, from 2001 to 2024, the final balance was a gain of 0.04 km², representing a percentage increase of 36.36% (Figures 4 A, B, and C).

The mosaic of uses class showed an increase in area in the periods from 2001 to 2012 and from 2001 to 2024, although it registered a reduction in the interval between 2012 and 2024. In 2001, this class occupied 5.49 km², expanding to 12.02 km² in 2012. In 2024, a decline was observed, with the area reduced to 10.05 km² (Figures 2, 3, 4 A, B, and C).

The other non-vegetated areas class also increased over the years analyzed in this study (2001, 2012, and 2024). In contrast, the other perennial crops class remained stable throughout the period, with a constant area of 0.001 km² in the three years evaluated (Figures 2, 3, and 4 A, B, and C).

With regard to the other temporary crops class, there was a marked reduction in area throughout the period analyzed. In 2001, this class occupied 22.23 km², decreasing to 13.54 km² in 2012 and reaching 3.11 km² in 2024 (Figures 2 and 3). Between 2001 and 2012, the area of this class decreased by 8.69 km², corresponding to a 39.09% reduction (Figure 4 A). In the period between 2012 and 2024, the decline was even more significant, totaling 10.43 km², equivalent to a reduction of 77.03% (Figure 4 B). Considering the entire interval analyzed, from 2001 to 2024, the cumulative loss was 19.12 km², representing a decrease of 86.01% (Figure 4 C).

Thus, analysis of the landscape in Sarandi between 2001 and 2024 reveals a territory in constant transformation, marked by the advance of urban sprawl and the consolidation of temporary crops. The replacement of crops reflects a trend toward productive specialization in northern and northwestern Paraná.

CONCLUSION

The study of land use and land cover dynamics in the municipality of Sarandi confirmed the hypothesis of accelerated expansion of the urban area and soybean cultivation. The data show that the urban sprawl has practically doubled in size in just over two decades, consolidating the process of spatial conurbation with the municipality of Maringá. In rural areas, the advance of soybeans over areas previously occupied by pastures and other temporary crops demonstrates the trend toward productive specialization observed in northern and northwestern Paraná.

On the other hand, the results also indicate an increase in the class of forest formations. This increase in vegetation cover, especially in recent decades, may be associated with stricter protection of Permanent Preservation Areas (APPs), in accordance with current environmental legislation.

This study is relevant because of its ability to provide input for land use planning in Sarandi. By documenting the transformations that have occurred in both urban and rural areas, the results provide a technical basis for public managers to reconcile economic development, urban expansion, and environmental conservation. It should be noted that the municipality is undergoing -territorial transition, in which planning must balance urban growth and agricultural productivity with the maintenance of environmental quality.

Finally, we recommend conducting complementary studies that incorporate supervised land use and land cover classifications based on images from the CBERS-4A satellite. The satellite has a spatial resolution of up to 2 meters in the panchromatic band, which allows for greater detail of landscape features. In this sense, it presents itself as a possibility for cartographic refinement and for obtaining more accurate results in the analysis of recent transformations in the studied territory.

ACKNOWLEDGMENTS

We would like to thank the Department of Geography at the State University of Maringá and the GEMA Institute for all their support.

REFERENCES

Altmann, A. L., Eckhardt, R. R., Rempel, C. (2009). Evolução temporal do uso e cobertura da terra - estudo de caso no município de Teutônia - RS - Brasil. Revista Brasileira de Cartografia, 61(03): 273-283. DOI: 10.14393/rbcv61n3-43648

Alvares, C. A. *et al*. (2014). Köppen's climate classification map for Brazil. Meteorologische Zeitschrift, 22(6): 711-728.

Brasil. Lei Nº 12.651, de 25 de maio de 2012. Disponível em: https://www.planalto.gov.br/ccivil_03/_ato2011-2014/2012/lei/L12651compilado.htm. Acesso em: 09 fev. 2026.

Conceição, R. P. da, Costa, C. E. A. de S., Progênio, M. F., & Lima, J. A. P. (2025). Análise temporal do uso e cobertura da terra em relação à expansão da soja no município de Paragominas-PA. Economia & Região, 13, e51018. DOI: 10.5433/2317-627X.2025.v13.51018

IBGE. Instituto Brasileiro de Geografia e Estatística. Cidades e Estados. (2025). Disponível em:https://cidades.ibge.gov.br/brasil/pr/sarandi/panorama. Acesso em: 27 jan. 2026.

IBGE. Instituto Brasileiro de Geografia e Estatística. Manual técnico da vegetação brasileira. (2012). Rio de Janeiro: IBGE. 276p.

MAPBIOMAS. Projeto MapBiomas – Coleção 10 da Série Anual de Mapas de Cobertura e Uso da Terra do Brasil. Disponível em: https://brasil.mapbiomas.org/colecoes-mapbiomas/. Acesso em: 09 dez. 2025.

MAPBIOMAS. O projeto. Disponível em: https://brasil.mapbiomas.org/o-projeto/#:~:text=O%20MapBiomas%20%C3%A9%20uma%20rede,da%20sociedade%20civil%20e%20empresas. Acesso em 18 jan. 2026.

Mandal, J., Ghosh, N., Mukhopadhyay, A. (2019). Urban Growth Dynamics and Changing Land-Use Land-Cover of Megacity Kolkata and Its Environs. Journal of the Indian Society of Remote Sensing, 47(10):1707-1725. https://doi.org/10.1007/s12524-019-01020-7

Nigro, G. T., Herek, L. C. S., Corrêa, R. C. G., Paccola, E. A. de S., & Figueiredo, N. C. (2025). Eficácia da legislação ambiental em Maringá-PR: uma análise temporal do uso do solo e da fragmentação florestal. Revista em Agronegócio e Meio Ambiente, 18, e14211. https://doi.org/10.17765/2176-9168.2025v18e14211

Nigro, G. T., Ferreira, M. E. M. C. (2021). Avaliação da recomposição florestal das áreas de fundo de vale na bacia do Córrego Cleópatra/Moscados, Maringá-PR. Boletim de Geografia, 39, 144-163, e58252. https://doi.org/10.4025/bolgeogr.v39.a2021.e58252

Rossatto, J. L., Schmidt, L. P., & Costa, P. A. (2020). O eixo conurbado entre Maringá e Sarandi (PR): um estudo geoeconômico. Revista PerCursos, 21(45): 202-231.

Silva, S. M. da, Lima, F. C. de, Maniesi, V., Lima, S. C. de, Covaleski, J. P., & Rezende, D. (2026). Uso e ocupação do solo na microbacia hidrográfica do rio Canaã a partir do MapBiomas. Revista Políticas Públicas & Cidades, 15(1), e3050. https://doi.org/10.23900/2359-1552v15n1-41-2026

Paiva, R. G., Nóbrega, M. T. (2010). Características socioeconômicas e evolução do uso do solo no norte central e noroeste paranaense. Estudos Geográficos, 8(1): 107-131.

Pessoa, A. M. dos S. *et al.* (2025). Dinâmica multitemporal da cobertura vegetal do estado da Paraíba. Revista Brasileira de Geografia Física, 18(01): 622-632. https://doi.org/10.26848/rbgf.v18.1.p622-632

Vale, J. R. B. *et al.* (2021). Crescimento urbano e impactos sobre a cobertura vegetal na área de influência da Avenida João Paulo II, região metropolitana de Belém-Pará. Revista Tocantinense de Geografia, 10(22): 164-180. DOI: 10.20873/rtg.v10n22p164-180